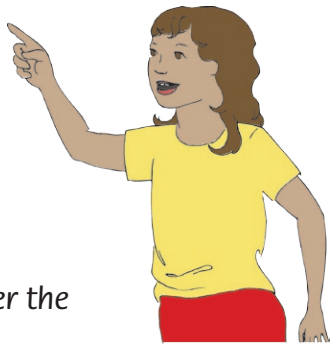
Exploration 4: Rotorcraft Flight and Lift

Students use appropriate terminology to describe the various stages of flight and discover that the lift force changes with the amount of air moved by the rotor blades.



Main Concept

Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be.

Goal

Students will conduct a scientific investigation and discover that the amount of air moved by the rotor blades affects the lift of the rotorcraft.

Objectives and Standards

Objectives	Standards
1. Students will describe the flight motion of a rotorcraft model. 2. Students will explain the aspects of a rotorcraft that affect lift. 3. Students will make scientific observations. 4. Students will work collaboratively with a team and share their findings.	**Partially Meets:** 2061: 4F (3-5) #1 **Addresses**: 2061: 1B (K-2) #1 2061: 1C (K-2) #2

Prerequisite Concepts

- *Air takes up space and is made up of particles that are too small to see.*
- *Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be.*
- *The rotor blades on a rotorcraft spin and provide the force to lift the rotorcraft.*

Links to Resources that Address Prerequisite Concepts

Robin Whirlybird Exploration #1: What is a Model?
Robin Whirlybird Exploration #2: How Do Rotorcraft Fly?
Robin Whirlybird Exploration on #3: How Do Rotors Create Lift?

Robin Whirlybird
http://rotored.arc.nasa.gov/story/robin18.html
http://rotored.arc.nasa.gov/story/robin3.html
Click on button "Rotorcraft Activities"

New Concepts

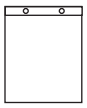
- Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be.

Schedule

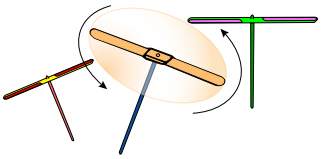
Allow 2-3 sessions of 10-20 minutes.

Materials

- Protective eyewear for each student, available from most school science supply stores and catalogs 
- Chalk or tape 

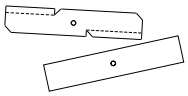

- Video clip of a rotorcraft taking off and landing, or, 
  - A computer connected to the internet so you can show the following page of the Robin Whirlybird web site: http://rotored.arc.nasa.gov/story/robin11.html or
  - A printout of the page (with the link above) of the Robin Whirlybird web site
- Chart paper 
- Drawing paper and crayons or coloring pencils   

- *One "flying dragonfly," which is a toy rotor that flies (shown right), for each pair of students*

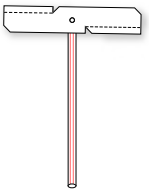


- *Small plastic commercially-made, toy helicopters with free spinning rotors*

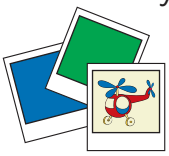
- *Lightweight paper propeller made using the template in this chapter's appendix*
- *Heavyweight paper propeller made using the template in this chapter's appendix*



- *Drinking straw with a lightweight paper propeller securely taped to one end*
- *Drinking straw with a heavyweight paper propeller securely taped to one end*



- *Pictures of various rotorcraft or the following page of the Robin Whirlybird Web site: http://rotored.arc.nasa.gov/story/robin15.html*



Safety Precautions

When using flying objects in a classroom, post very strict rules and review them with the students. All students MUST wear protective eyewear while any object is in flight. Clearly delineate one or more staging areas, preferably with students' input. Mark on the ground with chalk or tape, where all "test flights" will take place. Caution students to "secure the area" before beginning any "test flight."

Engage

1. *Draw on students' prior knowledge by asking them about their experiences with commercial flights:*
   - *Have you ever flown on an airplane?*
   - *What steps does the plane go through?*
   - *Have you watched airplanes at an airport?*
   - *What did you see the airplanes do?*
   - *Have you seen a helicopter?*
   - *What was the helicopter doing?*

2. *If you have a video clip of a rotorcraft taking off and landing, show it now.*

3. *If you do not have a video clip, then show the page of the Robin Whirlybird Web site or a picture of the page indicated in the Materials list.*

4. *Ask students to describe how the rotorcraft moves during different phases of flight. Write students descriptions of the stages on chart paper.*

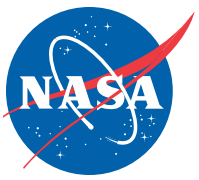
5. *Provide the following terms that describe various phases in a typical flight:*
   - ***Takeoff**: rotorcraft engines are activated and blades gradually spin faster. The rotorcraft lifts off the ground or landing area.*
   - ***Departure**: rotorcraft moves higher and away from the landing area and turns its body toward its flight direction. The rotor blades are spinning.*
   - ***En Route**: rotorcraft reaches steady flight (not ascending or descending) or maneuvers around tall buildings.*
   - ***Descent**: rotorcraft descends or loses altitude moving closer to the ground and orienting itself in the general direction of its landing area.*
   - ***Approach**: rotorcraft has the landing site in view, is slowing its speed and is preparing for landing.*
   - ***Landing**: the rotorcraft touches down on the ground. The rotors are deactivated and the blades gradually stop spinning.*

6. *Distribute drawing paper and ask students to create an illustration that explains how a rotorcraft flies during all or some of the following phases of its flight: takeoff, departure, en route, descent, approach and landing.*

7. *Have each student show their illustration and give their observation of the main rotor's rate of rotation.*

8. *Tell students that they are going to act as scientists studying what makes a rotorcraft takeoff, fly (en route) and descend.*
   - *Draw on students' prior knowledge of how scientists explore ideas.*
     - ☆ ***Question:** How do scientists study how things work?*
       Scientists use models to study how things work.
     - ☆ ***Question:** What is a model?*
       A model is something that is used to understand how the real thing works.

   - *Show students the following and ask them which could be used as a model to study rotorcraft flight:*
     - ☆ *The "flying dragonfly" toy rotor*
     - ☆ *Toy helicopters that do not fly*
     - ☆ *Drinking straw with a lightweight paper propeller securely taped to one end*
     - ☆ *Drinking straw with a heavyweight paper propeller securely taped to one end*



Explore

1. **Questions**:
   - *Using our model, how can we investigate how rotorcraft fly?*
   - *What can we find out about how rotorcraft fly?*

2. *Record students' responses on chart paper.*

3. *Tell students that they can release the model from various heights and spin the rotors at various speeds.*

4. *Ask students how they will record their observations.*
   Students may have some good ideas. Suggest that they draw pictures of the flight of their rotorcraft models.

5. *Discuss safety issues. Distribute the protective eyewear.*

6. *Emphasize proper observation skills and the importance of "thinking aloud."*

7. *Allow 10 minutes for open explorations.*

8. *Circulate through the group, recording students' observations, actions, ideas and questions.*
   Your written record of what the students are doing becomes the basis for discussion and further explorations.

9. *Monitor safety and proper use of materials.*

10. *Have students working in pairs draw a picture that depicts the results of their model's flight.*

Explain

1. *Gather students together for a discussion. Ask the group to discuss their observations about what happens during each stage of the rotorcraft's flight. Here are some possible responses:*
   - *The rotor blades are still before takeoff. Rotor blades come in different shapes and sizes.*
   - *The rotor blades start to spin. The rate of spin increases.*
   - *The rotorcraft takes off.*
   - *The rotorcraft lands and the rotor blades gradually stop spinning.*

2. Ask the following questions:
   - **Question:** What do the spinning rotor blades do?
     In the last exploration students learned that spinning rotor blades generate lift.

   - **Question:** What happens to the air when the rotor blades spin?
     Answer: The air moves.

   - **Question:** In which direction does the air move?
     Answer: The air gets pushed down and the rotorcraft moves up.

   - **Question:** What happens when the rotor blades spin faster?
     Answer: Students may guess that the air will move faster, so more air will be pushed down.

   - **Question:** What do you think would happen if the rotor blades spun faster and faster?
     Students might answer that the rotorcraft would fly higher and faster.
     Say: Let's think about that a little. What would happen if you rode your bicycle, skateboard, scooter (or other vehicle) faster and faster?
     Answer: It becomes more difficult to control the vehicle. There are limits to how fast you can make something go by simply making the motor run faster. Sometimes you have to change things about the vehicle itself.

3. Show students the pictures of rotorcraft.
   - **Question:** How are these rotorcraft different?
     Answer: Students observe that rotorcraft have different fuselages and a variety of blade shapes.

4. Ask students to draw the various shapes of rotor blades.

5. Ask students the following questions.
   - **Question:** What does a rotorcraft need in order to gain more lift?
     Answer: The rotorcraft needs to push down more air.

   - **Question:** How can a rotorcraft push down more air?
     Answer: There is "something" about the rotor blades that make them push down more or less air.

6. Tell students that in the following explorations they will discover how changing the shape and size of rotor blades affects the amount of air the blades push down.

Extend

1. Have a local rotorcraft enthusiast bring his/her remote controlled radio helicopter for a demonstration. Have the helicopter perform takeoff, hovering, forward and backward flight, up/down maneuvers and landing.

2. Ask a rotorcraft pilot to visit (or make a visit to a pilot's rotorcraft).

3. Have students prepare questions beforehand and assign specific students to ask specific questions.

Evaluate

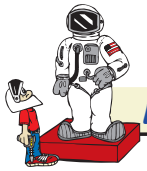
1. Distribute to the students in small groups, small plastic commercially-made, toy helicopters with free spinning rotors.

2. Have students gather in an open area and pretend to fly their helicopters
(Note: These types of helicopters are NOT models, they are merely toys.)

3. Tell students that they are going to fly their helicopters on a short flight. Give them instructions from takeoff through to landing and have them "fly" their helicopter in those phases.

4. Observe as the students "fly" their rotorcraft.

5. Have students draw a rotorcraft in flight and indicate the direction of the airflow and which part of the rotorcraft "pushes" the air down.



Further Exploration

1. Have students create their own lightweight and heavy weight paper propellers and attach them to drinking straws to investigate how long they stay aloft.

2. Another exploration could arise from a question about the shape of the rotor blade. Would changing the shape of the rotor blade change the way it flies or change its flight performance? If time and interest permit transform their ideas, questions, observations and/or hypotheses into additional investigations.

Appendix: Propeller Template